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Improving construction processes of concrete building structures using load limiters on shores

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ABSTRACT

This paper analyses the redistribution of maximum loads using a system of load limiters on shores in which the limiters yield at a given load and thus reduce the maximum load absorbed by the shores. For this analysis a finite element modelling (FEM) of an experimental building was developed in which load limiters had been fitted to the shores to restrict their maximum load to a given value. This was designed to: (a) optimise slab construction costs by using shores of lower load-bearing capacities, (b) improve safety during the construction of consecutive concrete slab floors by reducing maximum loads and redistributing loads amongst the shores; and (c) increase structural efficiency by more efficient use of the materials employed due to load redistribution. It has been estimated that using load limiters in this way can reduce total shoring costs in a building project by between 30% and 40%.

1. Introduction

Reducing building times and costs depends to a large extent on recovering all or part of the components used in the construction process in as short a time as possible. Although the stage at which formwork is removed depends on a number of factors, especially on the construction process employed, the characteristics of the work being carried out (type of concrete and loads) and even on ambient temperature and humidity, the commercial results are influenced to a high degree by considerations of structural safety, an important aspect since a significant percentage of collapses happen during the building process [1–3].

In order to achieve structural safety while at the same time reducing building times and costs, a technique known as clearing or partial striking is used in Spain and has been studied in depth by Moragues et al. [4], Alvarado [5], Alvarado et al. [6,7], Gasch [8] and Calderón et al. [9]. Authors such as Alvarado [5] and Alvarado et al. [6,7] consider that the load distribution on the shores supporting a floor under construction is not uniform and that the greatest weight is borne by the shores where slab deformation is highest. Shoring systems are thus designed to withstand the maximum load supported by the most heavily loaded shore, which means that the remaining shores are over-designed for the loads they have to bear.

2. Objectives and novelty of the study

This paper analyses the redistribution of maximum loads on shores by the use of load limiters. The idea of limiting loads on shores is a novel concept that aims to redistribute maximum loads by means of the plastic deformation of the limiters in order to control the load assumed by individual shores. This technique has beneficial effects on three of the most important aspects of constructing reinforced concrete slab floors that have already been subjected to a large number of studies, i.e. it optimises slab construction costs, improves safety in concrete slab construction and achieves higher structural efficiency.

Finite element models (FEM) can be used to study the evolution of redistributing maximum loads between shores and slabs using load limiters. For this study we chose to use the FEM developed by Alvarado [5] and Alvarado et al. [7] for an experimental building. We also studied the construction of a new building for the Fine Arts faculty of the Universitat Politècnica de València by means of an FEM developed by Gasch [8]. The role of the load limiters was included in both models.

3. Finite element modelling of the experimental building

3.1. Description of experimental building

A scheme of the experimental building can be seen in Fig. 1. This building comprised three storeys of 0.25 m thick reinforced

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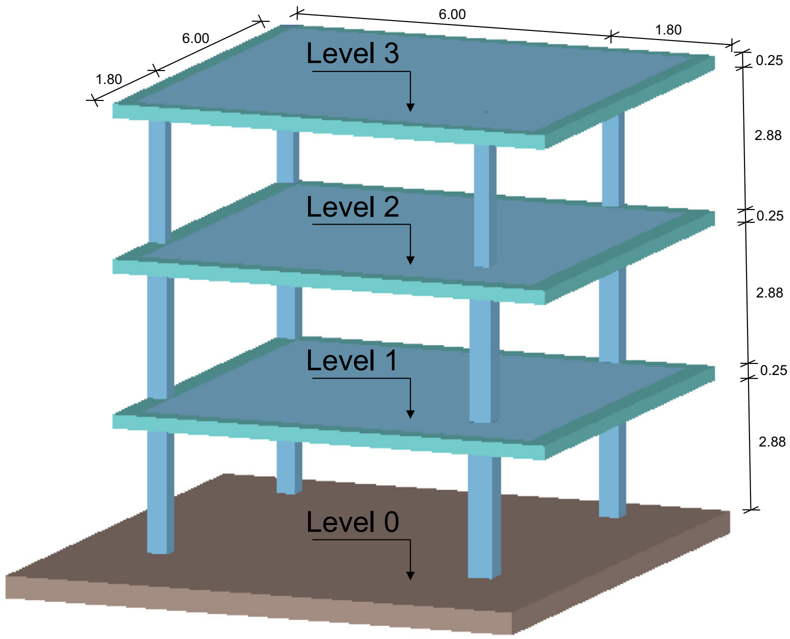

Fig. 1. 3D view of the experimental building.

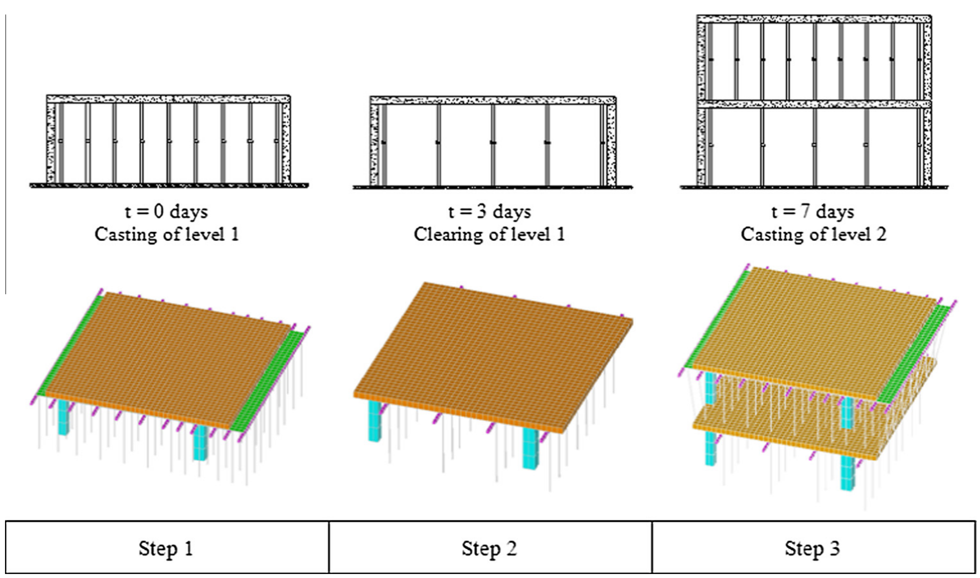

Fig. 2. Construction phases and load steps in experimental building (1).

concrete slabs, with a 6.00 m clear span between columns, and with a 2.75 m floor-to-ceiling height. The slabs were supported on rectangular section columns, cantilevered 1.80 m. The concrete used for all the building's components has a compressive strength of 25 MPa.

Each floor was constructed in three stages: shoring, clearing and striking. A uniformly distributed load was applied to the top floor to simulate the effect of an additional floor. Further details of the experimental study can be found in Alvarado [5] and Alvarado et al. [6].

3.2. Finite element modelling

Using the ANSYS 11.0 [10] commercial software and based on the FEM by Alvarado [5] and Alvarado et al. [7], we designed a model to simulate the experimental building described in Section 3.1 including load limiters on the shores. The geometric and mechanical characteristics of all the elements that formed part of the construction of the building were considered, as was the construction process by means of an evolutionary calculation, to enable the simulation of load transmission between slabs and shores during the construction of the building.

3.3. Hypotheses considered

The main hypotheses adopted for the FEM were the following (see Alvarado [5] for further details):

- The reinforced concrete slabs were assumed to have linear elastic behaviour with variations in stiffness with time.
- The columns were simulated with linear elastic behaviour with variations in stiffness with time.